Asset Price Spillovers from Unconventional Monetary Policy: A Global Empirical Perspective*

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This paper sheds new light on spillovers from U.S. monetary policies before, during, and after the 2008–09 global financial crisis by examining the behavior of select financial asset returns and incorporating indicators of the content of U.S. Federal Open Market Committee announcements. The impact of U.S. monetary policies is examined for systemically important and small open advanced economies. U.S. monetary policy surprise easings are found to have decreased yields in advanced economies post-crisis. The impact of the content of U.S. Federal Open Market Committee statements, coded using text analysis software, is also found to be significant but sensitive to the state of the economy.

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1. Introduction

The notion that monetary policy decisions by central banks can have international spillover effects is not new. In an integrated global financial system, the monetary policy stance of systemically important central banks will have global implications. Analyzing these spillover effects is important: not only are they likely to influence the success of domestic and international macroeconomic policies, but they also affect the likelihood of future international policy cooperation. This topic has taken on even greater urgency since the 2008–09 global financial crisis (GFC) prompted monetary authorities, especially in advanced economies (AEs), to intervene in financial markets on a scale previously unseen. Indeed, the introduction of unconventional monetary policies (UMPs) in some AEs is seen as a potential catalyst for policy spillovers.

This paper sheds new light on the impact of monetary policy spillovers by examining the response to global monetary policy surprises on select financial asset prices in AEs. Our principal contribution is to introduce a new critical element in measuring spillover effects by quantifying the impact of the surprise component in the content of certain announcements by central banks (viz., policy rate statements and minutes of policy committee meetings). The U.S. Federal Reserve (Fed) is the principal source of monetary policy surprises (MPS) in our analysis, and the sample considered in this study covers ten AEs. Expanding the coverage of countries under investigation is another contribution of our study. Five economies are considered systemically important advanced economies (SIAEs) while the remaining five countries in our data are small open advanced economies (SOAEs).

Central bank policy rates in AEs have remained low since the onset of the GFC. As a result, monetary authorities have placed even greater emphasis on policy communication (e.g., Blinder et al. 2008; Williams 2013; Yellen 2013). The policy of forward guidance (e.g., Charbonneau and Rennison 2015; Filardo and Hofmann 2014) is another manifestation of a strategy that highlights the importance of written and verbal communication in the conduct of monetary policy.

Financial markets closely monitor various forms of central bank communication and incorporate future interest rate expectations

into asset prices. It is well known, however, that the clarity of written communications varies, as does how such announcements are interpreted by financial markets (e.g., Blinder et al. 2008). Indeed, the impact of communications on expectations is not always predictable. Otherwise, central bankers themselves would not devote as much attention as they have in recent years to improving their communication with the public (e.g., Yellen 2013). Communication has taken on even more importance since several central banks introduced UMPs and drove policy rates to historically low levels (e.g., Cœuré 2017). Therefore, it is plausible that the content of central bank communication contains an additional element that is incompletely captured by standard proxies for monetary policy surprises that rely on financial asset price changes alone.

Rather than merely recording, say, the frequency of specifically chosen words that appear in monetary policy communications (e.g., tightening, loosening), it may be more fruitful to evaluate the overall content of central bank documents.[1] After all, central banks are known to choose their words carefully when crafting press releases and policy committee minutes. The content of central bank written communication reflects the monetary authority's views about both the current and anticipated state of the economy and how the stance of monetary policy is being determined. Consequently, whether the content of a document signals positive or negative sentiment or opinion, to give two examples, can be conveyed by a combination of several different words. Our approach to quantifying content in central bank communication is detailed in section 3.

Most studies of monetary policy spillovers (discussed in section 2) focus only on the period when the crisis began or when UMPs were launched. However, if we are to properly evaluate the effects of UMPs on international policy spillovers, it also seems desirable to consider the impact of surprises when monetary policy was more conventional. Therefore, following recent studies like Chen, Griffoli, and Sahay (2014), Gilchrist, Yue, and Zakrajšek (2016), and Rogers,

[1] There is nothing wrong, of course, with measuring the frequency with which certain words or expressions appear in a document. Indeed, some studies adopt this strategy (see below). The challenge, however, is to identify a set that provides a meaningful representation of the content of central bank documents. We return to this question later.

Scotti, and Wright (2014), our sample also includes a period before the GFC.

To preview the results, U.S. monetary policy surprises are found to lower yields in the United States and in other AEs. International spillover effects tend to be larger in the post-crisis period and affect the longer end of the yield curve. This indicates some success in the U.S. Fed's efforts to influence the longer end of the yield curve by implementing UMPs. More importantly, we find that the content of central bank statements affects the yields of several financial assets. The content of U.S. Federal Open Market Committee (FOMC) press statements is found to affect U.S. and international asset prices differently depending on the state of the economy. For example, in the pre-crisis period, optimistic and pessimistic language in FOMC communications is linked to whether the Fed's outlook is positive or negative, respectively. During the crisis, however, a shock via pessimistic language appears to have been transmitted through the risk-pricing channel. The content of FOMC meeting minutes appears to complement the impact of press statements, mainly during the crisis period and for longer-term yields. This is important because the former type of publication is supposed to reflect the diversity of views inside the committee, while the latter is supposed to communicate the FOMC's consensus view.

The remainder of this paper is organized as follows. Section 2 provides a brief literature review. Section 3 outlines the various facets and challenges involved in estimating the impact of verbal and non-verbal announcements of central bank actions on financial markets, and describes the data employed and econometric specifications. Section 4 summarizes our principal findings based on an investigation of ten economies, and section 5 concludes.

2. Literature Review

In what follows, we focus on the literature that relies on high-frequency data (i.e., daily or intradaily). Typically, studies estimate the relationship between changes in asset price returns—such as bonds, credit default swaps, equity prices, or exchange rates—and some indicator or proxy of monetary policy surprises. The simplest relationship is written as

$$\Delta q_t = \alpha + \beta MPS_t + \varepsilon_t, \tag{1}$$

where Δq_t is the daily (or intradaily) change or return on a particular financial asset and MPS_t proxies monetary policy surprises. When global sources of surprises are added, this gives rise to so-called spillover effects. In the pure event-study approach, Δq_t is evaluated at the time of a monetary policy announcement covering an event window of anywhere from a few minutes to a few days.

Given the relative size and significance of the U.S. financial system to the global financial system, U.S. MPS are the source of spillover effects in our study and have understandably attracted the most interest in the literature. Interest in U.S. policy spillovers is further reinforced by the unprecedented loosening of U.S. monetary policy through quantitative easing (QE) from 2008 to 2014.[2]

Several proxies for MPS have been proposed. They include differences between announced and expected monetary policy decisions, measured through surveys of market participants (e.g., Ehrmann and Fratzscher 2003, 2007) or changes in futures prices of monetary policy interest rates (e.g., Kuttner 2001); dummy variables for monetary policy announcements deemed to be surprises or to contain a surprise element based on a review of news articles (e.g., Rosa 2012); statements by central bankers (e.g., Aizenman, Binici, and Hutchison 2016); or by extracting the surprise component from financial market activity (e.g., Gürkaynak, Sack, and Swanson 2005). We adopt this last approach to measuring MPS, as it has been argued to be superior to other measures (Chen, Griffoli, and Sahay 2014).

Traditional methods used to measure MPS, however, may not capture the subtleties inherent in changing central bank communication over time. We therefore create a new set of variables that capture the surprise element of the *content* of central bank communications. This is viewed as complementing standard measures of MPS. The literature on the impact of this dimension of policymaking on financial markets is briefly discussed below.

It is usually assumed that announcements associated with UMPs are intended to reduce asset returns (i.e., $\beta < 0$). The surprise

[2] As international spillovers can be limited in type and severity by capital controls or other forms of financial repression, we restrict our focus to AEs with open capital accounts.

component might be the precise size of the intervention, as when the Fed announced in September 2012 a monthly program to purchase mortgage bonds. Verbal announcements, however, unaccompanied by immediate policy action, can also affect financial markets by boosting confidence; this was clearly observed in financial markets' reaction, for example, to European Central Bank (ECB) President Mario Draghi's July 2012 assertion to do "whatever it takes to preserve the euro."

Rogers, Scotti, and Wright (2014) examine the financial market effects of UMPs implemented by four major central banks (U.S. Fed, Bank of England, ECB, and Bank of Japan) for a variety of asset prices (equities, bonds, and exchange rates). They conclude that spillovers from the United States to the rest of the world are found to be relatively stronger than global spillovers to the United States, while UMPs affect the long end of the yield curve.[3] In contrast, during "normal" times, the short end of the term structure is influenced by monetary policy.

Other studies in this vein include Aït-Sahalia et al. (2012) and Bastidon, Huchet, and Kocoglu (2016). The former study finds that spillover effects intensified as the financial crisis progressed. The latter study focuses on the more recent sovereign debt crisis in the euro zone and concludes that insufficient forward guidance by the ECB blunted the monetary authorities' attempts at subduing stress in financial markets. Gilchrist, Yue, and Zakrajšek (2016)

[3]Their study relies mainly on robust least squares using intradaily data, but they also estimate vector autoregressions at the daily frequency that identifies shocks of interest via heteroskedasticity. The premise of the approach, established by Rigobon and Sack (2003) and since modified in several directions (e.g., Bohl, Siklos, and Werner 2007; Neely 2014; and Wright 2012), is that monetary policy decisions generate more volatility in financial markets around decision days (i.e., when the FOMC meets) as markets try to forecast what the central bank will say or do following the release of their policy statements. Similarly, Rosa (2016) finds that speeches by the Fed's Chair raise asset price volatility beyond what is considered "normal." Van Dijk, Lumsdaine, and van der Wel (2016) dispute this view, arguing that markets "set up" well in advance of FOMC meetings; thus, volatility is relatively lower around meeting days. We also estimated specifications for the United States that identified coefficients via heteroskedasticity using Lewbel's (2012) method (refer to the online appendix) after confirming that asset price volatility is indeed higher around the time of FOMC meetings, but our conclusions are unchanged.

find that the pass-through effects of unconventional and conventional monetary policy are roughly similar. Fratzscher, Lo Duca, and Straub (2018) suggest that international spillovers associated with Fed UMP announcements had comparatively small effects and diminishing returns. The International Monetary Fund (2013) conducted a broad investigation of spillovers of UMPs; they reported that the impact of monetary policy spillovers is magnified by indirect third-party effects. They also conclude that the "surprise" element of such policies exhibits diminishing effects as markets normalize.

Much has been made concerning the importance of measuring MPS using intradaily data to avoid having changes in yields being contaminated by other events. Nevertheless, many of the aforementioned studies do not find large differences between daily and intradaily data. Indeed, the vast majority of estimates of versions of equation (1) rely primarily on results at the daily frequency (e.g., Krishnamurthy, Nagel, and Vissing-Jorgensen 2017; Altavilla, Giannone, and Lenza 2016; and references therein).

Gürkaynak, Sack, and Swanson (2005) find intradaily estimates are "quite comparable" to results that rely on daily data. The only exceptions were the few days when an employment report was released or during a period when the Fed did not release a policy statement following the conclusion of an FOMC meeting.[4] Rogers, Scotti, and Wright (2014, p. 3) also acknowledge that whether MPS are properly identified at the intradaily frequency "may be questionable." More importantly, intradaily data can only provide inference about the immediate impact of an MPS. If we believe that monetary policy shocks can persist for a time, then an analysis at the daily frequency is not only suitable, it may actually be preferable. After all, as Shin (2017) points out, the "market" is not an individual and there is plenty of evidence that the impact of an announcement on asset prices will not be exhausted within a small window of time around a particular event (e.g., D'Amico 2016).

Turning briefly to the burgeoning literature on qualitative assessments of central bank communication, Blinder et al. (2008) is a recent survey which concludes that central bank communication has

[4]Gilchrist, Yue, and Zakrajšek (2016) assume a sixty-minute window "should allow the market a sufficient amount of time to digest the news contained in announcements," but no justification is provided for this choice.

a separate powerful impact on financial markets. It also stresses that additional work is needed to further our understanding of central bank communication on the transmission and effectiveness of monetary policy. More recently, speeches by several central bankers recognize that efforts aimed at improving central bank communication remain a work in progress (e.g., Haldane 2017 and references therein).

The content of central bank communication is typically evaluated by coding documents according to readers' interpretations (e.g., tightening or loosening of policy), constructed from speeches by central bankers (e.g., Ehrmann and Fratzscher 2007; Hayo, Kutan, and Neuenkirch 2015). Alternatively, content is quantified by estimating the frequency with which certain "bags of words" appear in documents (e.g., Meade, Burk, and Josselyn 2015; Steckler and Symington 2016). The use of a dictionary technique to capture the content or "sentiment" of central bank texts, which is also used in the present study, is becoming more prominent in the relevant literature (e.g., Hubert and Labondance 2017).

Despite central banks' efforts to improve the clarity of signals provided in official communications, interpreting the content of central bank announcements remains less straightforward than the signal from regular macroeconomic releases that are numerical in nature. As Andrade and Le Bihan (2013) demonstrate, even professional forecasters suffer from rational inattention and a sticky information set. More recently, Haldane (2017) suggests that the public's understanding of the content of central bank communication, including those who are immediately affected by decisions made by the monetary authority (e.g., firms and financial markets), is woefully inadequate.

Still, incorporating qualitative elements of monetary policy into our analytical toolkit is found to add considerable value to our understanding of the effectiveness of monetary policy and best practice in central banking (e.g., Hansen, McMahon, and Prat 2014; Neuenkirch 2012; Sturm and De Haan 2011). Furthermore, Hubert and Labondance (2017) find that the content of central bank statements does influence financial market expectations beyond the effects of monetary policy decisions and central bank forecasts. To our knowledge, no research has yet incorporated the content of central bank communication in the study of international spillovers of monetary policy.

3. Data and Econometric Specifications

The sample begins in June 2006 in order to include data near the peak of the last tightening cycle by the U.S. Federal Reserve (based on the level of the federal funds rate), and ends in December 2013. The precise starting point of various samples, however, is dictated by data availability across the economies considered. A long enough sample is needed so that pre- and post-crisis periods can be investigated separately. The subsamples considered are pre-crisis (June 1, 2006–September 14, 2008); crisis (September 15, 2008–September 30, 2009); post-crisis (October 1, 2009–December 31, 2013); and the euro-zone crisis (November 1, 2009–September 6, 2012).[5]

The basic hypothesis being investigated is that monetary policy surprises create cross-border spillover effects. Whereas previous research has focused on the effects of conventionally measured MPS, we add the spillover effects from a content analysis of press releases and monetary policy committee minutes. In addition, we are interested in whether the GFC and its aftermath amplified or moderated the impact of surprises in the content of central bank communications. Since the present study considers cross-country evidence, we also differentiate between domestic and global effects (i.e., primarily from the United States) of MPS.

The reactions to monetary policy surprises in countries cover several time zones. This provides a rationale for observing asset price changes over a two-day period (e.g., as in Ehrmann, Fratzscher, and Rigobon 2011).[6] When the U.S. FOMC's press releases and meeting minutes are published at 2:00 p.m. EST, European and Asian markets have closed for the day. This provides one argument for relying on two-day observations.

Three different indicators of asset price changes are employed. The change in the spread between three-month and ten-year

[5]The subsamples were chosen based on chronologies from three sources: the Federal Reserve Bank of St. Louis's timeline, the Federal Reserve Bank of New York's chronology, and a timeline prepared by the ECB. Dates were also cross-checked with available chronologies used in the literature; for example, Fratzscher, Lo Duca, and Straub (2018) and Rogers, Scotti, and Wright (2014).

[6]We are grateful to an anonymous referee for the suggestion. An earlier version of this paper (available on request) generates results using daily data, and our conclusions are broadly similar to the ones reported below.

sovereign bond yields is used to capture changes along the yield curve, while the two-day log return of ten-year sovereign bond yields captures spillovers at the longer end of the yield curve. The two-day log return of overnight index swap (OIS) with a one-year term to maturity captures fluctuations in short-term yields.[7] The sample includes five SIAEs (the euro zone, Japan, the United Kingdom, the United States, and Switzerland, which is included in this category due to the characteristics of its financial markets) and five SOAEs (Australia, Canada, New Zealand, Norway, and Sweden).

The content of central bank press releases that accompany monetary policy decisions is an important addition to the standard specification (i.e., equation (1)) because we seek to capture changes in the stance of monetary policy even when policy rates do not change.[8] The approach developed by Romer and Romer (1989, 2004) inspires our estimation strategy. They rely on the narrative approach to interpret the FOMC's intentions for the federal funds rate.[9]

Press releases and minutes may contain a component that incorporates a given central bank's expectations. We construct our indicators by applying an algorithm to capture different dimensions of a central bank's discussion about economic conditions and the policy stance.[10] There is the potential that an event, such as an economic news release, might affect the content of central bank statements and

[7]In a previous draft we also used the three-month and one-year LIBOR-OIS spread to capture the impact of spillovers on risk premiums. Due to space constraints, it has been removed from the draft. These results are, however, available in the online appendix.

[8]Alternatively, recent literature has estimated shadow policy rates in an attempt to capture what the policy rate would be if UMPs were incorporated (see Wu and Xia 2016 and references therein). As we are interested in estimating the impact of surprises in the content of certain central bank announcements, we do not pursue this line of inquiry.

[9]The authors identify the central bank's view about the economic outlook from other determinants. Hence, their measure is relatively free of the endogeneity problem that plagues conventional measures of monetary policy. Endogeneity arises in part because expectations of future changes in the monetary policy stance are influenced by current forecasts of the economic outlook that serve as the basis for setting the current stance of monetary policy.

[10]As suggestive evidence that our indicators of content of press releases and meeting minutes are not multicollinear with other measurements of MPS, we estimate the unconditional correlation coefficients with the first principal component of yields on U.S. Treasury futures on the date of monetary policy announcements, which range between –0.03 and –0.13.

asset prices on the date of a central bank announcement. To control for the possibility of an omitted-variable bias, we include ten significant macroeconomic news surprises in the United States (see table 1 for more details). That said, there are some challenges with the adopted strategy. One such limitation is that financial market participants often process central bank news through media reports (Hayo and Neuenkirch 2015). In addition, the news media sometimes concentrate their attention on changes in the language of central bank communications to convey change both in the current stance of policy and the economic outlook; the *Wall Street Journal*, for example, publishes a side-by-side comparison of the FOMC press releases after successive meetings to facilitate comparisons of changes in wording over time. However, the precise way that financial markets interpret U.S. FOMC statements, let alone changes in statements over time, is unknown.

To measure content, we apply a dictionary technique. We define lists of key words that aim to capture specific elements of the content of communication, and normalize the frequency with which the words in these dictionaries appear in each press statement and meeting minutes by the total word count of the document. Although central bank texts are intended for a general audience, words are carefully chosen.[11] The language used in press releases contains a combination of financial and everyday language. In the case of the FOMC minutes, likely read by a smaller and more specialized audience, participants in the meeting are aware that the transcript will be made public, and this has been found to influence not only what they say but also the language used (Acosta 2014; Meade and Stasavage 2008). Indeed, observers often look for clues about surprises based on

[11] The care taken in the language is clear from a reading of FOMC transcripts where officials are presented with alternative wording combinations not only depending on the likely future direction of the stance of monetary policy but also in an attempt to reflect the degree of consensus about the message the FOMC wishes to convey. Part B of the so-called Tealbook (previously part of the Bluebook) prepared for FOMC meetings has a section entitled "Monetary Policy Alternatives" that proposes a few alternatives for the language to be used in the FOMC's press release; this is discussed at length during each meeting. While staff proposals for policy statements date back at least to 1969, attention to detail in the choice of words has risen over time, with a clear boost around the time of the GFC.

Table 1. Description of Variables

Dependent Variable	**Description**	**Source**
Overnight Index Swaps (OIS)	One-year maturity; two-day log return. Note: Data not available for Japan; sample for United Kingdom starts in August 2007.	Thomson Reuters Datastream
Sovereign Bond Spread	Ten-year to three-month spread; difference over two days. Note: Sample period for Australia and euro zone begins June 2010 and January 2007, respectively.	Thomson Reuters Datastream (except euro zone)[a]
Long-Term Sovereign Bond Yield	Ten-year maturity; two-day log return.	Thomson Reuters Datastream (except euro zone)[a]
Independent Variable	**Description**	**Source**
U.S. Monetary Policy Surprises	Includes three variables: first difference of first principal component of U.S. Treasury futures (two-year to thirty-year maturity) on the day of (i) U.S. FOMC monetary policy statements, (ii) U.S. Fed UMP announcements (QE and forward guidance), and (iii) U.S. FOMC minutes release.	U.S. Treasury futures: Thomson Reuters Datastream Monetary policy announcement dates: central bank website
Monetary Policy Communication Content	Change in the content of monetary policy press statements.	Central bank websites
Domestic Monetary Policy Announcements	Dummy variable equal to one on the day of monetary policy press statement.	Central bank websites
Surprise U.S. Macroeconomic Announcements	Difference between the observed value and the most recent forecast, normalized over the sample period. Includes ten key U.S. macroeconomic announcements: GDP growth, unemployment, non-farm payroll, jobless claims, retail sales, consumer credit, durable goods orders, manufacturing, housing starts, and existing home sales.	Econoday
U.S. Purdah Period	Dummy variable equal to one on dates where the purdah period is active for the U.S. FOMC.	Central bank website
Lag of Dependent Variable	See dependent variable.	See dependent variable source

[a]Euro-zone bond yield and bond spread data are taken from the ECB, which includes issuers with triple-A ratings and uses the Svensson (1994) model. We also used the first principal component of asset returns of the major euro-zone economies; our results remained unchanged.

how much, or little, dissent there is in FOMC deliberations (Madeira and Madeira 2016).

Our dictionaries combine those constructed by the DICTION 6.0 algorithm (see Hart, Childers, and Lind 2013), which was initially developed to analyze political texts, and Loughran and McDonald (2011), who developed dictionaries to reflect the unique characteristic of language used in financial texts. Although using an algorithm is a more objective measurement of content, additional sets of words were also considered to incorporate language commonly used in central bank communications. As shown by Loughran and McDonald (2016), because the dictionary approach to text analysis can be sensitive to the choice of words in the dictionaries, we removed words that are believed to be ambiguous in the context of central banking; for example, crisis, unemployment, risk, and protection.[12] Although these terms do typically capture negative or positive sentiment, they are used in more general or clinical ways by central banks.[13] For similar reasons, the constructed dictionaries include inflections rather than stemming words. For example, "stabilize" and "stabilizing" are included in the optimism dictionary, but not "stability," as it is used more ambiguously in the context of central bank communication; using its stemmed form ("stabil-") would not achieve this end.

Our approach can therefore be seen as a method that mixes the qualitative with the quantitative. The three dimensions of content in central bank documents that we are interested in are certainty,

[12]Loughran and McDonald (2016) criticize DICTION because its dictionaries are not ideally suited to capture the tone of finance-related documents. However, they fail to acknowledge that DICTION can accommodate dictionaries constructed by the user.

[13]For example, central banks refer to risk (i.e., upside, downside, or balanced) and unemployment trends in most monetary policy statements. But they are described in a more clinical way; therefore, we cannot say with confidence that additional uses of these terms in any given statement means that the committee has become more pessimistic. A similar argument could be made about the word "crisis"; the GFC might be referred to as an event that led to some bad outcomes, but reference to the event might not imply that the central bank is currently more pessimistic. Furthermore, when we are actually in crisis conditions, central bankers tend to refer to economic or financial "turmoil" (which is included in the pessimism dictionary) rather than "crisis." Despite efforts to adjust for ambiguous meaning, these issues clearly highlight a key challenge of using textual analysis: meaning is often expressed by a complex combination of words.

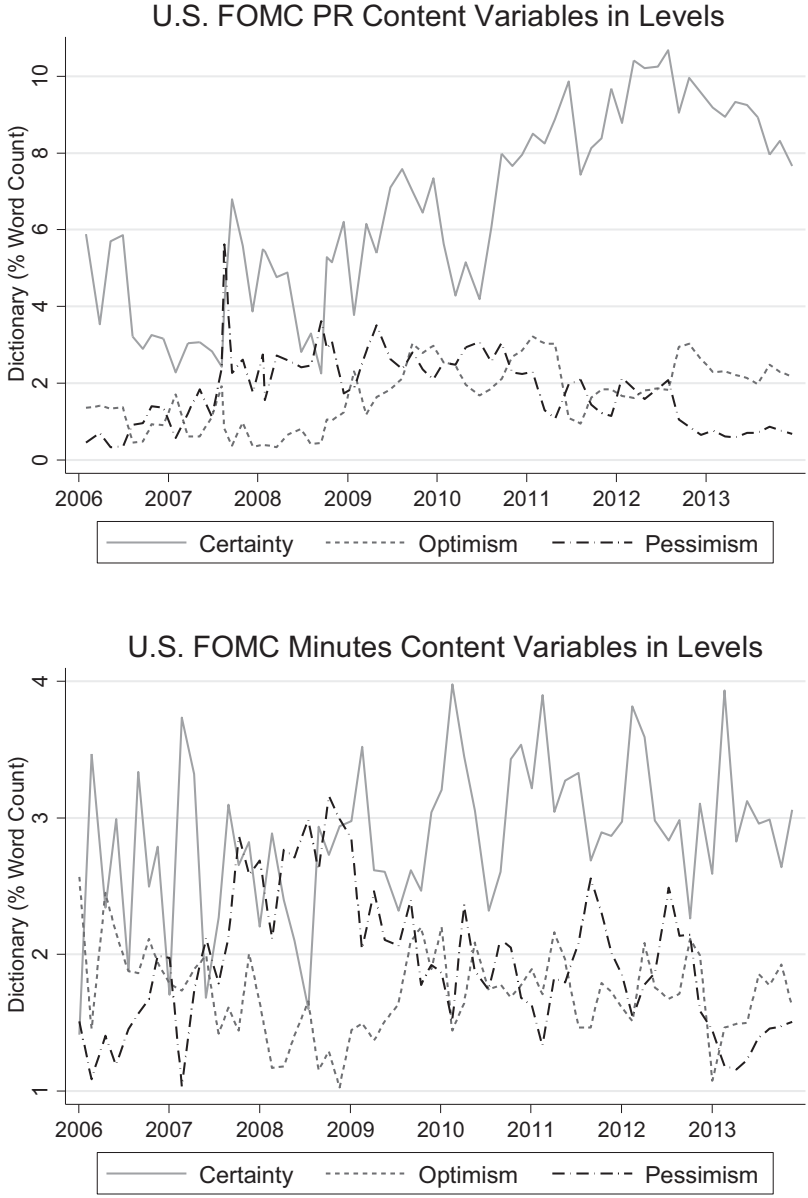
optimism, and pessimism.[14] Briefly, certainty tries to capture the degree to which monetary policy committees make assertions about the state of the economy and the policy stance, and conveys the sense that the committee is speaking with one voice. Earlier research finds that dissent (i.e., a reduction of agreement) inside the FOMC provides important clues about the conduct of U.S. monetary policy (e.g., Thornton and Wheelock 2014). Optimism attempts to capture FOMC language that conveys positive views about the current state of the economy and the contribution made by the current stance of monetary policy. This opens the door to a surprise tightening. In contrast, pessimism attempts to capture sentiment that suggests existing conditions are unsatisfactory. Hence, this raises the possibility of a surprise easing. An online appendix (available at http://www.ijcb.org) provides further details about the composition of these dictionaries.

Figure 1 plots these content variables in levels—the percentage of words that describe content from a dictionary in the total word count of the document—for U.S. FOMC press statements and meeting minutes. The content of central bank communication changes over time, either due to changes in current economic conditions or through deliberate efforts to change the committee's approach to communication, as identified by Meade, Burk, and Josselyn (2015). The graphs illustrate that expressions of certainty, and to a lesser extent optimism, have increased over time in FOMC press releases, while pessimism increased during the crisis and decreased over the post-crisis period. A similar trend is observed in the expression of certainty in FOMC meeting minutes; however, it is less pronounced. Differences in the trends in content of meeting minutes and press releases can be attributed to the fact that press releases are short and deliberately crafted statements, whereas minutes, which are much longer and more detailed, are more descriptive of circumstances.

The surprise element of the content of communication that affects changes in financial asset returns can be measured several ways. The simplest is to take the change in the content variable; therefore, the

[14]In earlier drafts we also considered other indicators of content, but the chosen measures of content likely represent what sentiment financial markets are looking for in central bank press releases and minutes.

Figure 1. U.S. FOMC Content Variables in Levels



Notes: Plotted are the content variables (certainty, optimism, and pessimism) in levels for the U.S. FOMC's press releases (top panel) and meeting minutes (bottom panel). The data represents the percentage of words from each dictionary in the total word count of the document. The sampling frequency is approximately eight times per year on the dates when the FOMC releases its monetary policy statements and meeting minutes. See section 3, and the online appendix provides for further details about the construction of the communications content variables.

surprise content is equal to the change in the percentage of words that convey a certain sentiment (according to a specified dictionary) in the total word count.[15] Other proxies were considered, with little impact on the conclusions.[16]

A rarely discussed consideration in evaluating the empirical evidence about the impact of UMPs is that there are subtle, and not so subtle, differences in both the timing and the coverage of "events" likely to affect asset prices. Some researchers, including Rogers, Scotti, and Wright (2014) who adopt a time-series approach to estimate specifications similar to ours, have resorted to identification through heteroskedasticity (see footnote 3, and Rigobon 2003).[17] We also found differences in the volatility of yield changes and spreads between FOMC meeting days and the remaining days in the sample.[18] We estimate our specifications in the time-series setting using robust least squares (Huber's (1981) M-estimator) to mitigate the impact of outliers that can affect some parameter estimates.

[15]It is worth repeating that observers form expectations about whether the stance of policy will change and not how the wording of press releases, let alone the content of minutes, will change. Whether press releases in successive meetings are written as if the authors start from a blank page is debatable, but even if this is the case, asset return volatility and not their levels will be affected (Ehrmann and Talmi 2016).

[16]There is a possibility that change in the content of statements from meeting to meeting reflects surprises between meetings, rather than a surprise on the day of the meeting. Other studies have found, however, that the central bank statements are themselves a source of new information (e.g., Hubert and Labondance 2017). Furthermore, as we use daily data, these surprises would be priced into asset prices before the date of an announcement. We considered two alternative measures of surprise in the content of central bank statements. The first approach standardizes the percentages over the full sample so that the mean is equal to zero and the standard deviation is equal to one. The second approach takes the deviations from the mean value obtained during the pre-crisis sample. Communications in the pre-crisis period may be taken as a benchmark where less emphasis was placed on the choice of words, as the policy rate was not constrained by the effective lower bound; thus, any deviations from this sample could be taken to be a shock in the content of communications.

[17]The same result cannot be said to hold in all of the other economies in our data set, paralleling the results reported in Rogers, Scotti, and Wright (2014). Identification through heteroskedasticity does not, however, generate different conclusions. See the online appendix for some estimation results.

[18]Summary statistics that support this view are relegated to the online appendix. Also, see footnote 3.

The benchmark specification, an extended version of (1), is written

$$\Delta q_{it} = \alpha_i + \beta \boldsymbol{MPS}_{it} + \theta^j \boldsymbol{\Delta C}^j_{it} + \gamma \boldsymbol{X}^j_{it} + \rho \Delta q_{i(t-1)} + \varepsilon_{it}, \quad (2)$$

where the subscript i identifies the economy in question while the superscript j identifies whether the determinant of changes in asset prices is domestic or global, where the latter is assumed to originate from the United States. Specification (2) also allows for persistence in asset price changes; Δq represents the two-day log asset return or change in spread, $\boldsymbol{MPS}$ is a vector of monetary policy surprises in the United States, $\boldsymbol{C}$ is a vector of indicators that define the content of the language used by policymakers (as defined above), and $\boldsymbol{X}$ is a vector of additional domestic and global control variables, while Δ is the first-difference operator.[19] U.S. MPS is defined by changes in the first principal component of two-, five-, ten-, and thirty-year U.S. Treasury futures on the date of key monetary policy announcements. Using this methodology, we construct three MPS variables: the first captures the day of U.S. FOMC press releases, the second captures the release of FOMC meeting minutes, and the third captures the dates of U.S. Fed UMP announcements (including QE and forward guidance). Traditionally, the first principal component represents the "level effect" following a MPS, and an increase in MPS represents a surprise loosening of U.S. monetary policy.

In a variant of (2), we allow for the differential impact of tightening versus loosening surprises by interacting $\boldsymbol{C}$ with a Heaviside indicator that identifies episodes where MPS > 0. For this purpose, we use the second principal component of the U.S.-based MPS proxy, as this reflects the impact of monetary policies when short-term interest rates are reduced relative to long-term yields (i.e., a twist of the yield curve; also see Gürkaynak, Sack, and Swanson 2005, and

[19] In estimating (2) and (3) we include dummy variables to capture the announcement of domestic monetary policy decisions, as well as the fact that central banks typically practice purdah—a black-out on central bank news or announcements around days when the monetary policy committee meets (e.g., Ehrmann and Fratzscher 2009). We also include surprise macroeconomic announcements. Refer to table 1 for more details on these measurements. In a previous draft, we added the policy uncertainty measure developed by Baker, Bloom, and Davis (2016) for the United States and other economies where data were available, but this variable proved to be highly insignificant and was dropped.

Rogers, Scotti, and Wright 2014). Normally, a reduction in short-term rates, other things equal, is seen as a loosening of monetary policy. A positive value means that observed yields are lower than expected, which translates into a surprise loosening of policy. The Heaviside variable is labeled $\mathrm{I}(MPS^2 > 0)$, where "2" identifies the second principal component of U.S. MPS. We convert all instances when the policy surprise variable is positive to a dummy variable set equal to unity (and zero otherwise). The specification is thus written

$$\Delta q_{it} = \alpha_i + \beta \boldsymbol{MPS}_{it} + \theta^j \boldsymbol{\Delta C}^j_{it} + \theta \boldsymbol{\Delta C}_{it} * \mathrm{I}(MPS^2 > 0) + \gamma \boldsymbol{X}^j_{it} + \rho \Delta q_{i(t-1)} + \varepsilon_{it}, \tag{3}$$

where $\boldsymbol{MPS}$ and $\boldsymbol{C}$ are as described above, and j includes both domestic and U.S. variants. The purpose of this additional analysis is to verify whether asset prices respond to the surprise content of central bank statements asymmetrically when monetary policy is loosened or tightened. Readers are referred to table 1 for more information on the dependent and independent variables and data sources.

4. Econometric Evidence

Originally, we estimated U.S. spillovers to each economy in the data set. But this generates a considerable number of coefficients, making it challenging to summarize the main findings. Hence, we relegate these estimates to the online appendix. Instead, we present separate estimates for the United States and consider two separate panels consisting of (i) the large and systemically important economies (SIAEs) and (ii) the small-open economies (SOAEs) in the data set.[20] The coefficient estimates of β and θ^{US} from specification (2)—that is, the estimates of the impact of U.S. MPS and content of FOMC documents—are presented in table 2 for the United States and table 3 for a group of SIAEs and SOAEs. Estimates for subsamples are presented in figure 2 to illustrate how the size and influence of spillovers from U.S. MPS have changed over time.

[20]We are grateful to one of the referees for the suggestion. The panel-based results mirror those obtained from pairwise economy estimates.

Table 2. U.S. Regression Estimates

	One-Year OIS	Bond Spread	Ten-Year Yield
Press Release	−0.01	−0.49***	−0.12***
	(0.05)	(0.10)	(0.03)
UMP Announcement	−0.03	0.13	−0.01
	(0.06)	(0.12)	(0.04)
Minutes Release	0.04	−0.29**	−0.12***
	(0.06)	(0.14)	(0.04)
PR: Certainty	−0.20	−2.36***	−0.2
	(0.47)	(0.89)	(0.28)
PR: Optimism	0.44	−0.71	−0.14
	(1.09)	(2.02)	(0.64)
PR: Pessimism	0.68	2.51*	−0.12
	(0.68)	(1.29)	(0.41)
Minutes: Certainty	−0.47	1.21	0.46
	(0.91)	(2.21)	(0.71)
Minutes: Optimism	0.90	6.4	1.05
	(1.77)	(4.24)	(1.36)
Minutes: Pessimism	0.53	1.57	1.15
	(1.67)	(3.64)	(1.16)
N	1,572	1,335	1,338
R^2 Adjusted	0.29	0.36	0.29

Notes: Estimates for model (2) using robust least squares with standard errors in parentheses. Only the coefficient estimates on the domestic monetary policy surprise (MPS) and U.S. FOMC communications content (C) are reported; the full results are available in the online appendix. *, **, and *** indicate statistical significance at the 10, 5, and 1 percent level, respectively.

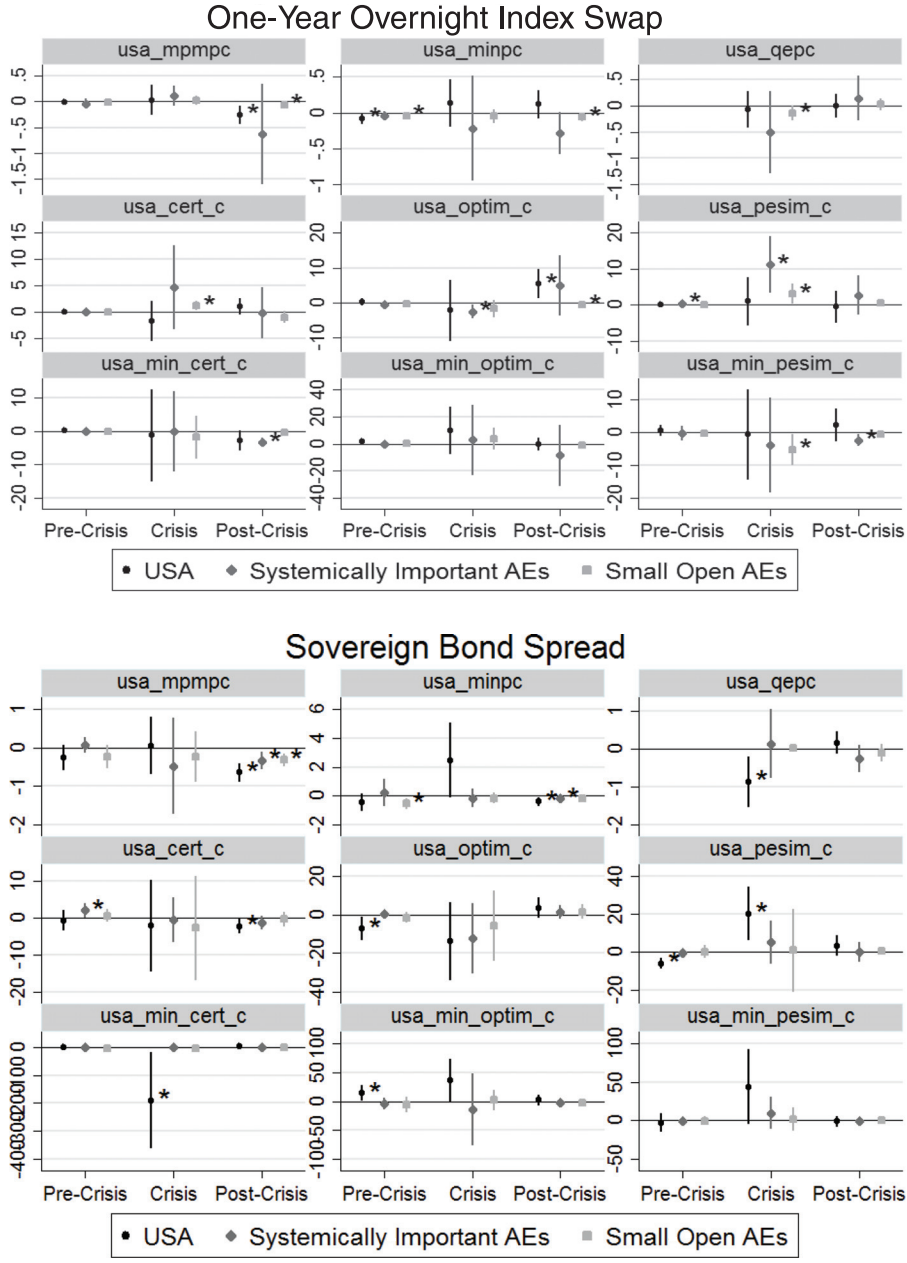
The results suggest that the impact of a positive MPS, that is a surprise easing of U.S. monetary policy, typically reduces yields in both the United States and other AEs. International spillovers appear to be larger in the post-crisis period, and they tend to have a more persistent impact on longer-term sovereign bond yields, consistent with the findings of Rogers, Scotti, and Wright (2014). While the impact of U.S. policies is sometimes relatively greater in magnitude for short-term money markets, this result is found less consistently across sample periods and groups of countries. Unsurprisingly,

Table 3. Panel Regression Estimates of Spillovers

	One-Year OIS	Bond Spread	Ten-Year Yield
A. Group 1: Systemically Important Advanced Economies (SIAEs)			
Press Release	−0.15	−0.13	−0.06***
	(0.08)	(0.13)	(0.01)
UMP Announcement	−0.07	−0.09	−0.04***
	(0.06)	(0.09)	(0.01)
Minutes Release	−0.22	−0.12	−0.06*
	(0.11)	(0.17)	(0.02)
PR: Certainty	0.56	0.29	0.14**
	(1.01)	(0.50)	(0.04)
PR: Optimism	−0.49	−1.75	−0.49**
	(1.34)	(1.00)	(0.14)
PR: Pessimism	0.80*	−0.41	−0.29*
	(0.22)	(0.25)	(0.09)
Minutes: Certainty	−1.58	−1.06	−0.57
	(1.02)	(1.32)	(0.43)
Minutes: Optimism	−4.96	−3.87	−1.27*
	(3.30)	(3.66)	(0.49)
Minutes: Pessimism	−2.21	1.32	−0.25
	(1.60)	(2.03)	(0.46)
N	3,942	5,460	6,036
R^2 Adjusted	0.13	0.12	0.26
B. Group 2: Small Open Advanced Economies (SOAEs)			
Press Release	−0.01	−0.19	−0.06***
	(0.01)	(0.10)	(0.01)
UMP Announcement	−0.02	−0.03	−0.04*
	(0.03)	(0.06)	(0.02)
Minutes Release	−0.06	−0.26***	−0.06***
	(0.03)	(0.03)	(0.01)
PR: Certainty	−0.42	−0.11	0.03
	(0.37)	(0.73)	(0.08)
PR: Optimism	−0.91*	−0.29	−0.33**
	(0.37)	(0.53)	(0.10)
PR: Pessimism	0.33	0.44	0.06
	(0.27)	(1.05)	(0.06)
Minutes: Certainty	−0.23	−1.52	−0.16
	(0.12)	(1.39)	(0.18)
Minutes: Optimism	−0.06	−2.67	−0.24
	(0.51)	(1.83)	(0.29)
Minutes: Pessimism	−1.16**	0.20	−0.05
	(0.26)	(0.61)	(0.25)
N	7,515	6,522	7,479
R^2 Adjusted	0.31	0.25	0.32

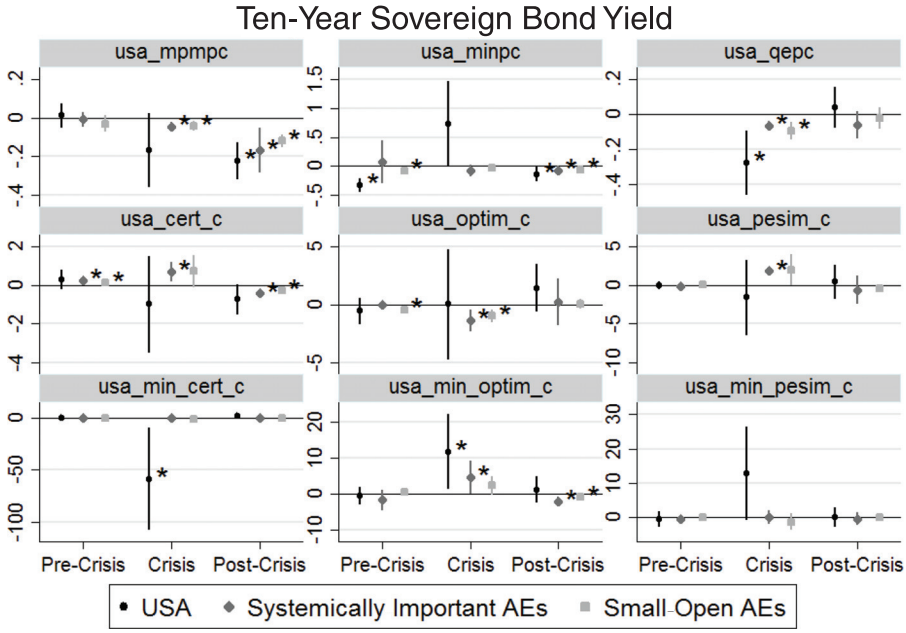
Notes: Estimates for model (2) fixed effects with clustered standard errors in parentheses. Only the coefficient estimates on the monetary policy surprises in the United States (MPS^{US}) and U.S. FOMC communications content (C^{US}) are reported; the full results are available in the online appendix. *, **, and *** indicate statistical significance at the 10, 5, and 1 percent level, respectively. Group 1 are systematically important advanced economies (includes the euro zone, Japan, Switzerland, and the United Kingdom). Group 2 are small open advanced economies (includes Australia, Canada, New Zealand, Norway, and Sweden).

Figure 2. Coefficient Estimates of U.S. Monetary Policy Surprise by Subsample and Group of Countries



(*continued*)

Figure 2. (Continued)



Notes: Plotted are the coefficient estimates and 90 percent confidence intervals for U.S. monetary policy surprises and U.S. FOMC content variables for each dependent variable by sample period. These are the same coefficient estimates that are in tables 2 and 3 (also see section 3), but are estimated over three different sample periods: The pre-crisis period is from June 1, 2006 to September 14, 2008; the crisis period is from September 15, 2008 to September 30, 2009; and the post-crisis period is from October 1, 2009 to December 31, 2013. * indicates that the coefficient estimate immediately to the left is statistically significant at the 10 percent level. *min* refers to the minutes, *mpm* refers to the press releases following a monetary policy meeting, *c* refers to the fact that content is measured, *cert* is certainty, *pes* is pessimism, *optim* is optimism, and *qe* refers to quantitative easing announcements.

U.S. assets are most strongly affected by U.S. MPS. With respect to short-term yields, SOAEs see a decrease in the one-year OIS following a surprise policy easing in the United States. Similar to Chen, Grifolli, and Sahay (2014), we find the impact on longer-term yields appears to be widespread during the post-crisis period, having a statistically significant impact at least at the 95 percent confidence

level on assets in both SIAEs and SOAEs, and even after controlling for the content of central bank press releases and minutes. This suggests that the U.S. Fed's efforts to affect the longer end of the yield curve during the crisis and post-crisis periods were not only effective for U.S. assets, but also spread globally. U.S. Fed UMP announcements also appear to be effective in flattening the yield curve and long-term yields in the United States. As with the findings of IMF (2013), UMP announcements had a larger impact during the crisis than in the post-crisis period. Spillover effects from these announcements also lowered long-term yields in other AEs.

The coefficients of the content of U.S. FOMC statements are also included in tables 2 and 3, and in figure 2. Our coefficient plots reveal that the impact of U.S. Fed communications varies across countries and time. Expressions of certainty in U.S. FOMC press releases in the pre-crisis and crisis periods increased long-term yields in both SIAEs and SOAEs. This effect may be related to the idea that sentiment conveying certainty may increase financial market participants' confidence in the economic outlook. During the crisis, expressions of certainty also increased short-term yields in SOAEs; this result could be related to the U.S. Fed's efforts to convey with some immediacy confidence in its ability to address the crisis effectively, which could have resulted in a rise in policy rates in countries that were not as badly affected by the crisis (e.g., Australia, Canada, and New Zealand). In the post-crisis period, however, certainty in press communications tended to reduce long-term yields in other AEs, while it flattened the U.S. yield curve. This appears to reflect a role for global easing from the Fed's bold and sizable QE policies introduced during the crisis and the FOMC's willingness to take more action if necessary. Certainty may also reflect agreement inside the FOMC about maintaining ultra-loose monetary policy for longer than would be expected according to the underlying data or the mechanical application of, say, a Taylor rule.

Turning to the effect of optimism in FOMC press statements, we similarly conclude that its impact varies depending on whether the U.S. economy was in crisis or not. In the pre-crisis period, optimism flattened the yield curve in the United States, perhaps in anticipation of higher short-term yields. During the crisis period, expressions of optimism decreased both short-term and long-term

Table 4. Testing for Statistical Differences

	One-Year OIS		Sovereign Bond Spread		Ten-Year Bond Yield	
Period	**SIAE**	**SOAE**	**SIAE**	**SOAE**	**SIAE**	**SOAE**
Pre-crisis to Crisis	17.29	5.56	1.13	0.01	172.71	4.15
	(0.000)	(0.018)	(0.289)	(0.935)	(0.000)	(0.042)
Crisis to Post-Crisis	3.65	8.30	2.34	0.00	6.39	4.63
	(0.056)	(0.004)	(0.126)	(0.955)	(0.012)	(0.032)

Notes: The table shows the χ^2 statistic and p-value for the Wald test of statistically significant differences in the coefficients between periods. The model is estimated using seemingly unrelated estimation with country fixed effects and clustered standard errors. The pre-crisis period and crisis period, and the crisis and post-crisis period coefficient estimates are compared.

yields in other AEs; this may reflect optimism in the ability of the Fed's policy response to quell the liquidity crisis and reduce financial market volatility. In the post-crisis period, however, optimistic language from the FOMC had a relatively large, positive impact on U.S. short-term yields, and a small, positive effect on SOAE short-term yields; this increase is consistent with the notion that a positive outlook for the U.S. economy could be associated with a tightening of monetary policies.

What stands out most from including a role for the pessimistic content of central bank communication is that the impact is considerably larger during crisis conditions, relative to both the pre-crisis and post-crisis periods at the short end and long end of the yield curve (also see table 4). Pre-crisis, pessimistic content flattened the sovereign bond yield curve in the United States, perhaps reflecting expectations of lower future interest rates. During the crisis period, however, an increase in pessimistic content in FOMC press statements is estimated to increase bond spreads in the United States, which is likely associated with declining short-term yields. Pessimistic sentiment increases short-term and long-term yields in other AEs. This may reflect pessimistic language operating through risk-pricing channels. Risk premiums in both short-term and long-term markets are known to be affected in an environment associated with high uncertainty that characterizes a financial crisis.

Turning briefly to the surprise content of FOMC meeting minutes, the largest impact is clearly observed during the crisis. In this period, an increase in optimism contained in meeting minutes increases long-term sovereign bond yields in the United States and other AEs. This captures the impact of a more favorable outlook for the economy. On the other hand, an increase in expressions of certainty in meeting minutes decreased long-term bond yields in the United States and flattened the yield curve. This provides further evidence that the FOMC's communication of its resolve to maintain an accommodative monetary policy stance—and to consider further easing through UMPs—helped keep long-term bond yield low. Pessimistic content in meeting minutes decreased short-term yields in SOAEs during the crisis, and in SIAEs in the post-crisis period, perhaps a reflection that a weak U.S. economy was associated with a more accommodative policy stance globally. In general, however, it seems that FOMC press releases significantly affect asset prices domestically and internationally regardless of the state of the U.S. economy, while meeting minutes mostly serve as an important additional source of information principally during the crisis period.

Generally, the estimation results suggest the impact of the content of U.S. FOMC statements differs across countries and over time. Results from estimates of equation (3), which permits asymmetric effects, confirm this finding (see the online appendix). Changes in the pessimistic content of central bank statements have a different effect on asset prices when there is a surprise loosening of U.S. Fed monetary policy. Specifically, pessimistic content shocks increase short- and long-term yields, and steepen the yield curve when there is a surprise loosening. Otherwise, the impact is negative. This result indicates that pessimism is associated with heightened uncertainty or risk. The upshot of the foregoing results is that the language of central bank communication acts as an additional variable that significantly affects financial asset prices.

5. Conclusion

Unprecedented actions by central banks in major AEs continue to draw the attention of policymakers and academics. We empirically examine the behavior of financial asset prices in ten economies in

response to U.S. monetary policy surprises (MPS). We find that since the GFC, the impact of MPS easings has been to decrease yields in most economies. We also conclude that spillovers from U.S. monetary policy to other systemically important economies as well as small open advanced economies have become larger and more persistent since the end of the GFC. Overall, our empirical results highlight a neglected source of influence on yields before, during, and after the financial crisis: the impact of central bank communication. Our study also provides evidence that central bank communication matters more during periods of financial turmoil and when the policy interest rate is at the zero or effective lower bound. Specific aspects of communication are found to have different effects depending on the state of the economy. However, while the content of FOMC press releases influences yields throughout the entire sample, the minutes appear to exert significant effects on asset prices only during the crisis.

Expressions consistent with certainty significantly reduce long-term yields in the post-crisis period, a reflection of the FOMC's agreement and resoluteness in maintaining accommodative monetary policy since the financial crisis began. Equally important, the spillover effects to the other economies considered, while smaller, are in the same direction. Pre-crisis, greater certainty in central bank content translates into higher long-term yields. We find that during the crisis, short-term yields in the small open economies in our data set rose when FOMC written content was consistent with more certainty about the conduct of monetary policy.

Optimism increases short- and long-term yields in the post-crisis period as financial participants begin anticipating the tightening of the global monetary policy stance. The impact at the short end of the maturity structure is relatively larger. As with the other content variables included in the various estimated specifications, the impact of central bank content is larger for U.S. financial assets than for financial assets elsewhere. Optimism is also found to flatten the yield curve during the crisis, a result that also holds pre-crisis.

Changing pessimism in the content of central bank press releases and minutes also matters, but the impact is relatively larger during the crisis. Spreads during this period are found to increase when there is more pessimism signaled by the Fed, and this sentiment also spills over into the other economies examined here. Indeed, a rise in

pessimism is seen as producing a rise in interest rates outside the United States. The bottom line then is that while central bank communication by the Fed can have negative consequences abroad, in the form of higher short-term interest rates, the same communication can also be beneficial because long-term yields decline as the Fed, and the other systemically important central banks, implemented unconventional monetary policies.

There are a number of worthwhile extensions to our analysis that might be contemplated. First, key speeches by central bankers could also be coded using the text software employed in this paper, as this is an additional source of spillovers that is not considered in this study. Second, there may be an element of surprise in the change in the shadow policy interest rate, in addition to the content of press releases. The reason is that prior to the crisis, market participants had become used to discerning the stance of monetary policy via some version of the eponymous Taylor rule. During the crisis, however, some of the central banks in our study reached the effective lower bound (United States, United Kingdom, and the euro zone). Hence, the stance of monetary policy could no longer be easily measured via the observed policy rate. Instead, shadow policy rates have been estimated. We leave these extensions to future research.

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